the left-hand page, and so above the plates, which are immediately under the pupil's eyes. The printing and the plates (the only figure that does not please us is the oval on Plate II.) leave nothing to be desired.

We proceed to point out a few matters which we think admit of improvement. Plate II. in the definition of a circle *invarying* is used; why not "constant?" The construction of Fig. 6 (Plate IV.) is hardly satisfactory to our view, though it is one very frequently given; the tangent to the two arcs is not obtained by a legitimate method. We cannot make out the definition of an harmonic *mean* given on Plate VII., but the *means* are correctly constructed. In Fig. 31 (text), for G H : H A, read *vice versa*. We may remark that it is a curious fact that the approximative construction given in Fig. 87 is true in the cases of regular figures of three, four, and six sides. In Fig. 99 (text) read "through F and E." In Fig. 112 (text) arcs "cutting in C," not G. Constructions to Figs. 123, 125 give particular ellipses; so in the case of the parabolas in Figs. 138, 139, we note that certain figures are stated to be *co*-centric and certain curves have assym ptotes. In Fig. 271 (text) read to cut in "I and H." We object, on pure geometric grounds, to the constructions in Figs. 278, &c., where a line is found equal to the semi-circumference of a circle, &c.; also the inscribed circle of a square and the inscribed triangle are stated as being in the ratio, triangle : circle : square, as 2 : 3 : 4. In Fig. 279 (text) the two last A's should be D. The construction to Fig. 297 (to draw a line to bisect any triangle from a given point within it) is new to us, and on a cursory examination of it we have not satisfied ourselves of its correctness. In Fig. 314, for X Y, read Z Y. In Fig. 316, "the square on," or some such words have been omitted. In Fig. 323 the limitations have not been laid down. In Fig. 329, "*join* point X," &c.; in 331, for "rectangle" read "parallelogram." These trivial oversights will serve to show how correctly the text has been printed.

OUR BOOK SHELF

Observaciones Magneticas y Meteorologicas del Colegio de Belen de la Compañia de Jesus en la Habana, 1873 *y* 1874. (Habana, 1874 and 1875.)

THE observations made at the College of the Society of Jesus, Havana, are peculiarly valuable for the fulness and care with which they are made, and for the completeness with which the observations themselves and the monthly means and extremes are given in each monthly table and its accompanying diagram. The diagrams, which have been published in their present improved form since June 1873, and which exhibit on one sheet the two-hourly observations as made daily from 4 A.M. to 10 P.M. of all the meteorological and magnetical elements, will very much facilitate the study of those inquiries which deal with the inter-relations of these elements. To these observations are added the daily amounts of the rainfall and evaporation—the latter being of great interest as contributing to our knowledge of the evaporation in inter-tropical regions, of which so little is known. Whilst only the daily amounts of the rainfall is given, each hour during which rain falls is noted, together with the hour of occurrence of thunder and other irregularly recurring phenomena. As regards the diurnal variations of the wind it changes from about S.E. in the early morning, through E. and N.E. to N.N.E. its most northerly point, which is usually reached about 2 P.M., and thence in the reverse direction through N.E. and E. to E.S.E., which is reached about 10 P.M. The diurnal velocity is at the minimum at 4 A.M., rises to the maximum at 2 P.M., and thence falls steadily to the minimum. The N. and N.E. winds are decidedly the strongest, and the S.E. the weakest, the ratio being as two to one; in other words, the sea-breeze blows with double the velocity of the land-breeze at this station.

LETTERS TO THE EDITOR

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts. No notice is taken of anonymous communications.*]

Blowpipe Analysis

MR. HUMPIDGE (vol. xiii. p. 208), on the entirely gratuitous assumption that I use "commercial reagents"—whatever that term may mean—says that there is probably iron in my soda.

To this I only reply that I will undertake to show pyrologically the presence of 0·01 per cent. of iron oxide in a fragment of a salt the size of a pin's head; and that, when Mr. Humpidge can do as much without using the dangerous test potassium ferrocyanide (which itself contains iron), I will admit his right to assume that he knows his tools better than other workmen.

No one has ever doubted the proportional relativity in precipitating power between a drop and a gallon of water, but if Mr. Humpidge will only do me the justice not to mutilate my statements in the reproduction, he will repeat that a *precipitate* could not be shown in a drop of water "*on a fused mass* upon an aluminium plate."

W. A. ROSS

Shepherd's Bush, W., Jan. 14

The D-line Spectrum

WILL Prof. Stokes give us the reason of his now holding that his first—to all appearance, extremely rational—conclusion, that, in consequence of "the powerful affinities of *sodium*, it could not exist in a *free* state in the flame of a spirit-lamp," is "erroneous"?

Shepherd's Bush, W., Jan. 8 W. A. ROSS

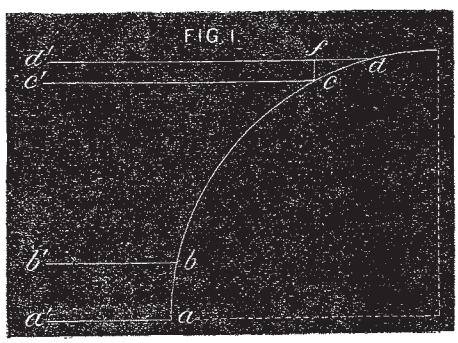
The Difference of Thermal Energy transmitted to the Earth by Radiation from different parts of the Solar Surface.

THE tenor of certain letters received from scientific persons on the above subject induces me to lay the following statement before the readers of NATURE:—

1. Previous to undertaking a systematic investigation of the mechanical properties of solar heat, I examined thoroughly the merits of Laplace's famous demonstration relating to the absorptive power of the sun's atmosphere, proving that only one-twelfth of the energy developed by the sun is transmitted to the earth. The demonstration being based on the assumption that the sun's rays emit energy of equal intensity in all directions, my initiary step was that of testing practically the truth of that proposition. It has been asserted that Laplace did not propound the singular doctrine involved in such a proposition, I therefore feel called upon, before proving its unsoundness, to quote the words employed by the celebrated mathematician. (See "Mécanique Céleste," tome iv. page 284.) Having called attention to the fact that any portion of the solar disc as it approaches the limb ought to appear *more brilliant* because it is viewed under a *less angle*, Laplace adds:—"Car il est naturel de penser que chaque point de la surface du soleil renvoie une lumière égale dans tous les sens." Let *a b c d*, in the annexed diagram, Fig. 1, represent part of the border of the sun, and *b a*, *c d*, small equal arcs; *a d'*, *b b'*, *c c'*, *d d'*, being parallel rays projected towards the earth. Laplace's theory asserts that owing to the concentration of the rays the radiation emanating from the portion *d c* transmits *greater* intensity towards the earth than *b a*, in the proportion of *c d* to *f c*. The proposition is thus stated in "Mécanique Céleste": "Call θ the arc of a great circle of the sun's surface, included between the luminous point and the centre of the sun's disc, the sun's radius being taken for unity; a very small portion *a* of the surface being removed to the distance θ

from the centre of the disc, will appear to be reduced to the space $a \cos \theta$; the intensity of its light must therefore be increased in the ratio of unity to $\cos \theta$."

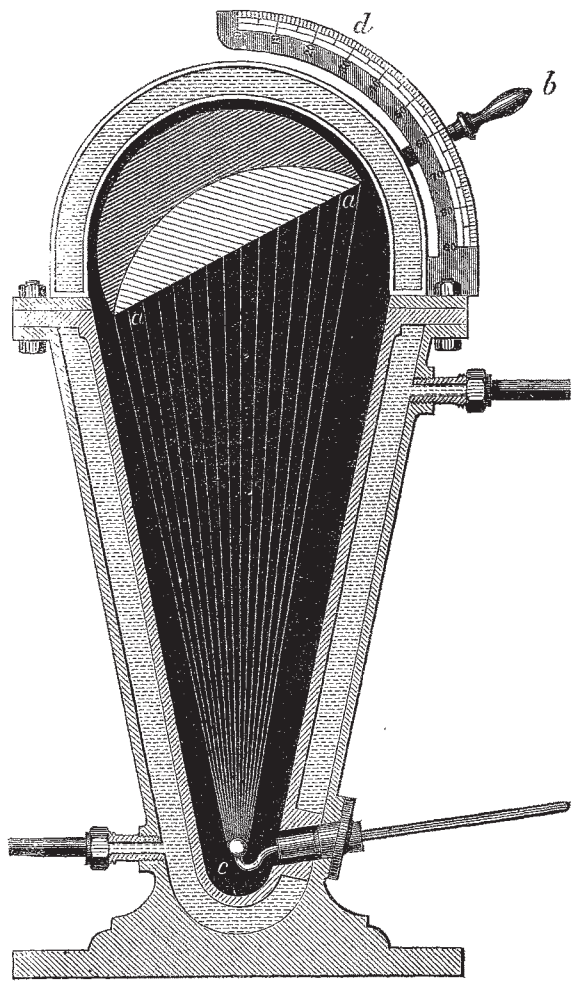
2. In order to disprove the correctness of the stated demonstration, I have measured the relative thermal energy of rays projected in different directions from an incandescent metallic disc, by the following method:—Fig. 2 represents section of a conical vessel covered by a movable semi-spherical top, the vessel being surrounded by a jacket through which water may be circulated. A revolving circular disc, *a a*, composed of cast iron, the back being semi-spherical and protected by fire-clay, is suspended across the top of the conical vessel supported by horizontal journals attached at opposite sides. The angular position of the disc is regulated by a radial handle, *b*, connected to one of the journals; the exact inclination to the vertical line being ascertained by means of a graduated quadrant, *d*. An instrument, *c*, capable of indicating the intensity of the radiant heat transmitted by the incandescent disc, is applied at the bottom of the conical vessel. The mode of conducting the experiment is extremely simple. The movable cover and its lining of fire-clay having been removed, the cast-iron disc is heated in an air-furnace to a temperature of 1,800° F. It is then removed by appropriate tongs, and suspended over the conical vessel, the lining and cover being quickly replaced. The temperature, shown by the instrument at the bottom of the conical vessel, resulting from the action of the radiant heat of the disc, is then recorded for every tenth degree of inclination. The investigation, it may be briefly stated, shows that the temperatures imparted by radiation to the recording instrument is exactly as the sines of the angles of inclination of the disc. Hence, at an inclination of 10° to the vertical line, the temperature imparted to the thermometer is scarcely one-sixth of that imparted when the disc



faces the thermometer at right angles; yet in both cases an *equal amount of surface of an equal degree of incandescence* is radiating towards the instrument! Laplace and his followers have evidently overlooked this important and somewhat anomalous fact, proving that radiation emanating from heated bodies is incapable of exerting full enegy in more than one direction. Our practical experiments with the revolving incandescent disc have thus fully demonstrated the truth of the proposition intended to be established, namely, that the rays emanating from incandescent planes do not transmit heat of equal energy in all directions, the energy transmitted being as stated, proportionate to the sines of their angle of inclination to the radiating surface.

3. The next step in the investigation of solar heat, before adverted to, was that of measuring the radiant energy transmitted in a given direction by an incandescent solid metallic sphere. For this purpose I employed a double conical vessel similar to the one represented in Fig. 2, the incandescent sphere being suspended over the conical vessel in the same manner as the revolving disc. The nature of the arrangement will be readily understood by inspecting the annexed diagram, which represents four spheres, Figs. 3, 4, 5, and 6, each sphere being divided into four zones, A, B, C, and D, occupying unequal arcs, but containing equal convex areas. Semi-spherical screens composed of non-conducting substances were applied below each sphere, provided with annular openings, arranged as shown in the diagram. Through these annular openings the radiant heat from the incandescent zones, D, C, B, and A, was transmitted to the thermometers, *f*, *g*, *h*, and *k*, respectively. Père Secchi, and other followers of Laplace, will be surprised to learn that when the suspended sphere was maintained at a temperature of 1,800° F., the radiation from the zone C, Fig. 4, imparted a temperature of 27°·49 F. to the thermometer *g*, while the radiation from the zone A, Fig. 6, imparted only 6°·19 F. to the thermometer *k*. Let us bear in mind that the radiating surface *l m* of the zone A is equal to the radiating surface *p q* of the zone C. The stated great difference of temperature produced by the radiation from zones of equal area furnishes additional proof that Laplace based his remarkable analysis on false premises. "The sun's disc ought to appear more brilliant towards the border, because viewed under a less angle," we are told by the great analyst. The instituted practical tests, however, prove positively that the energy of the rays projected from the border of an incandescent sphere is greatly diminished *because viewed under a less angle* from the point occupied by the recording thermometer.

FIG. 2.

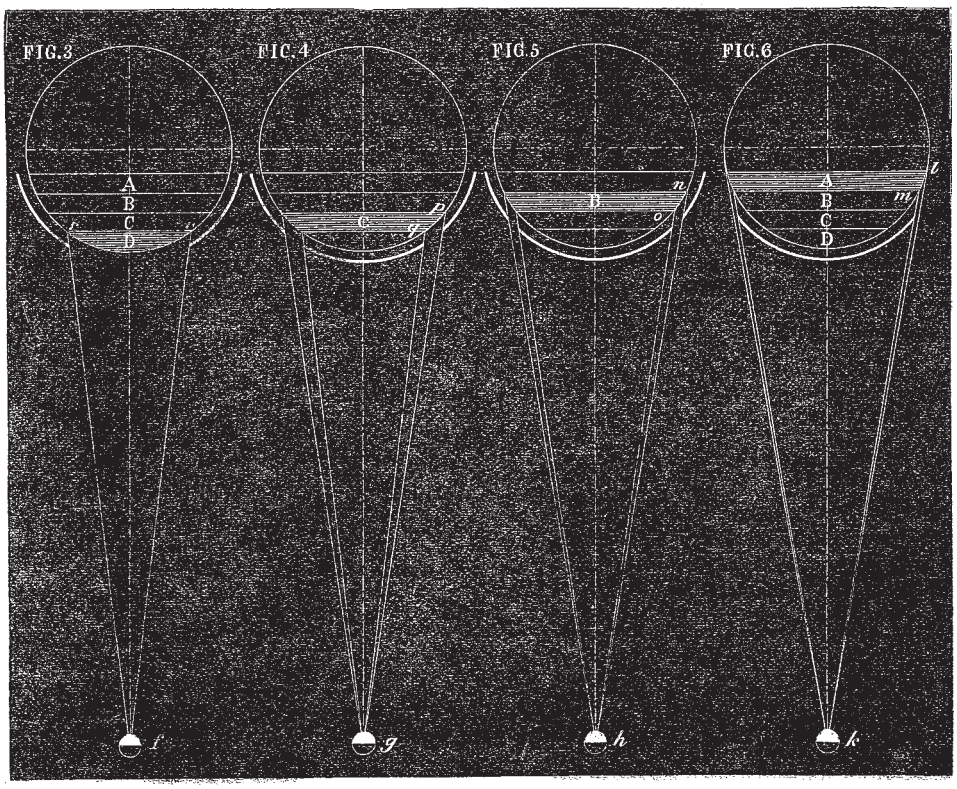


4. The result of our experiment with the revolving incandescent disc shows that if the small arc *b a*, in Fig. 1, be reduced until the field represented by *b' a'* becomes equal to the field represented by *c' d'*, the radiant energy transmitted through each of those fields will be alike; the reason being that the number of rays of diminished intensity passing through *c' d'* will be as much greater than the number of rays of maximum intensity passing through *b' a'*, as *c d* is greater than the reduced *b a* = *f c*. It should be observed that *c d* is so small that we may without appreciable error regard it as a straight base, and *f c* as the sine of the angle *c d f*. It follows from this demonstration that if the solar atmosphere exerted no retarding influence, the radiant heat transmitted towards the earth would be alike for equal areas of the solar disc—more correctly, for areas subtending equal angles, since the receding part of the solar surface is at a greater distance from the earth than the central part.

Encouraged by the practical result of the instituted investiga-

tion, I devised the method described in NATURE (vol. xii. p. 517), showing that the polar and equatorial regions of the solar disc transmit radiant heat of equal intensity to the earth, and that the sun emits heat of equal energy in all directions. Adopting Secchi's doctrine relating to the retardation suffered by calorific rays in passing through atmospheres, viz., that the diminution of energy is as the depth penetrated by the rays, it may also be shown by an easy calculation based on the result of our investigations, that the absorption by the solar atmosphere cannot exceed one-seventh of the radiant energy emanating from the photosphere.

5. Concerning the plan resorted to by the Director of the Roman Observatory, and others, of investigating the sun's image instead of adopting the method of *direct* observations, I will merely observe that the information contained in the several works of the Roman astronomer furnishes the best possible guide in judging of the efficacy of *image investigation*. Let us select his account of the investigations conducted between the



19th and 23rd of March, 1852. Having pointed out that in these experiments it was impossible to approach within a minute of the edge of the sun, and that during a later observation—date not mentioned—he had approached within a minute, the investigator observes: "But at this extreme limit, even making use of the most accurate means of observation, we find difficulties which it is impossible to overcome completely." In addition to this emphatic expression regarding the difficulties encountered, the author adds: "Moreover, it is impossible to study the edge alone, for the unavoidable motions of the image do not admit of its being retained at exactly the same point of the pile; we have therefore been unable to push the exactness as far as we hoped; and we have discontinued the pursuit of these researches, although the results obtained are quite interesting." (See revised edition of "Le Soleil," vol. i. p. 205.) It is needless to institute a comparison between a system of which its founder speaks so despondingly, and one which enables us to push our investigations to the extreme limit of the solar disc, admitting of entire zones being viewed at once, instead of only small isolated spots.

J. ERICSSON

The Glow-worm in Scotland

THE Glow-worm is not uncommon on the Island of Cumbrae, Buteshire. I have seen it there occasionally for the last thirty years (see vol. xiii. pp. 188, 208). DAVID ROBERTSON

Millport, Island of Cumbrae, Jan. 18

OUR ASTRONOMICAL COLUMN

STAR WITH SUSPECTED LARGE PROPER MOTION.—It would appear by a communication from Prof. Winnecke, Director of the Imperial Observatory at Strasburg, that the large proper motion exhibited by a comparison of Argelander's positions of the ninth magnitude star, No. 11237-8 of Oeltzen's catalogue (southern zones) with Taylor's observations at Madras in 1838 or 1839, to which reference was lately made in this column, does not really exist, there being evidently an error in Taylor's mean place for 1840 given at p. clxiii. of vol. v. of the Madras Observations. Prof. Winnecke finds that the differences of right ascension and declination between this star and Oeltzen 11226, are sensibly the same as at the time of Argelander's observations (1851), and the latter star is known to have but very small, if any, proper motion. Taylor's star must therefore be struck off the list of cases of great proper motion lately given.

ATLAS — 27*f* PLEIADUM.—A very interesting observation was made at Strasburg on the occasion of the occultation of this star—a Struve's *difficillima*—on the 7th of the present month. As we recently stated, this star does not appear to have been seen double since the last Dorpat observation in 1830. On the 7th inst., however, Herr Hartwig observing at Strasburg with an excellent Fraunhofer, of 42 lines aperture, power 159, remarked that the star did not disappear instantaneously; after the principal mass of light had vanished there remained a luminous point for about six-tenths of a second, a circumstance which favours the duplicity of the object, notwithstanding the failure of recent efforts to divide it. It brings to our recollection Burg's observation of the